

# THE QUESTION ON THE RESOLUTION OF BLD LU-226

Hua-shun Zhang

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The BLD has been successfully operated. Although the resolution has been theoretically estimated before<sup>[1]</sup> and the measured resolution by means of a dc electron beam is :  $\tau_{FWHM} = 2.3^\circ$ ,  $\tau_{FW90\%} = 5.5^\circ$ <sup>[2]</sup>, there is still some question about the resolution :

(1) The measured data of the beam length is longer than the theoretical estimation.

(2) The theoretical expected resolution (for  $V_{rf} < 1$  kV) is roughly:

$$\tau_r \doteq \frac{2.0}{V_{rf}} + 1.0 \quad (^\circ) \quad (1)$$

The measured beam length continuously decreases with the rf scanning amplitude, as shown in Tab.1.

Tab.1 The measured beam length vs. rf scanning amplitude

$V_{rf}$ (relative)	case	$\tau_{FWHM}(^\circ)$	case	$\tau_{FW90\%}(^\circ)$
1.2	(I)	19.4	(II)	34.6
2.2		12.6		26.8
2.4		11.2		24.4
$V_{rf}$ (relative)	case	$\tau_{FWHM}(^\circ)$		
2.0	(III)	16.1		
2.33		14.1		
2.67		13.0		
3.0		12.4		
3.33		11.4		

Assuming that

$$\tau_{measured} = \sqrt{\tau_b^2 + \tau_r^2} \quad (2)$$

$$\tau_r \doteq k/V_{rf} \quad (3)$$

the coefficient  $k$  can be estimated. For case (I)—(III),  $k$  is roughly constant for each case. This means the resolution time  $\tau_r$  is still roughly linearly decreasing with increase of  $V_{rf}$ . And the minimum resolution time  $\tau_{rmin}$  at the maximum  $V_{rf}$  now used ( $\sim 0.9$  kV) can be estimated as follows:

Tab.2 The estimated resolution

case	(I)	(II)	(III)
$\tau_{rmin}$	8.9°(HM)	13.5°(90%)	8.7°(HM)

That means: the minimum resolution time ( $V_{rf} \sim 0.9$  kV) may be  $\sim 8.8^\circ$  at half maximum in order,  $\sim 13.5^\circ$  at 90% of maximum. This is much longer than the measured by a dc beam and also longer than the theoretically estimated value. Moreover, it is not negligible to correct measurement of the beam length. For example, if the estimated  $\tau_{rmin}$  is correct, the measured beam length and the actual beam length may be as follows:

Tab.3 The correction of the measured value

case	$\tau_{measured}$	$\tau_{actual}$
(I)	11.24°	7.0°
(II)	24.4°	20°
(III)	13.54°	10.3°

(3) As  $V_{rf}$  increases, the peaks of measured beam phase diagrams gradually move, as shown in Fig.1. The other interesting fact is : when  $V_{rf}$  changes, only the front edges of waveform move, while the falling edges only change little.

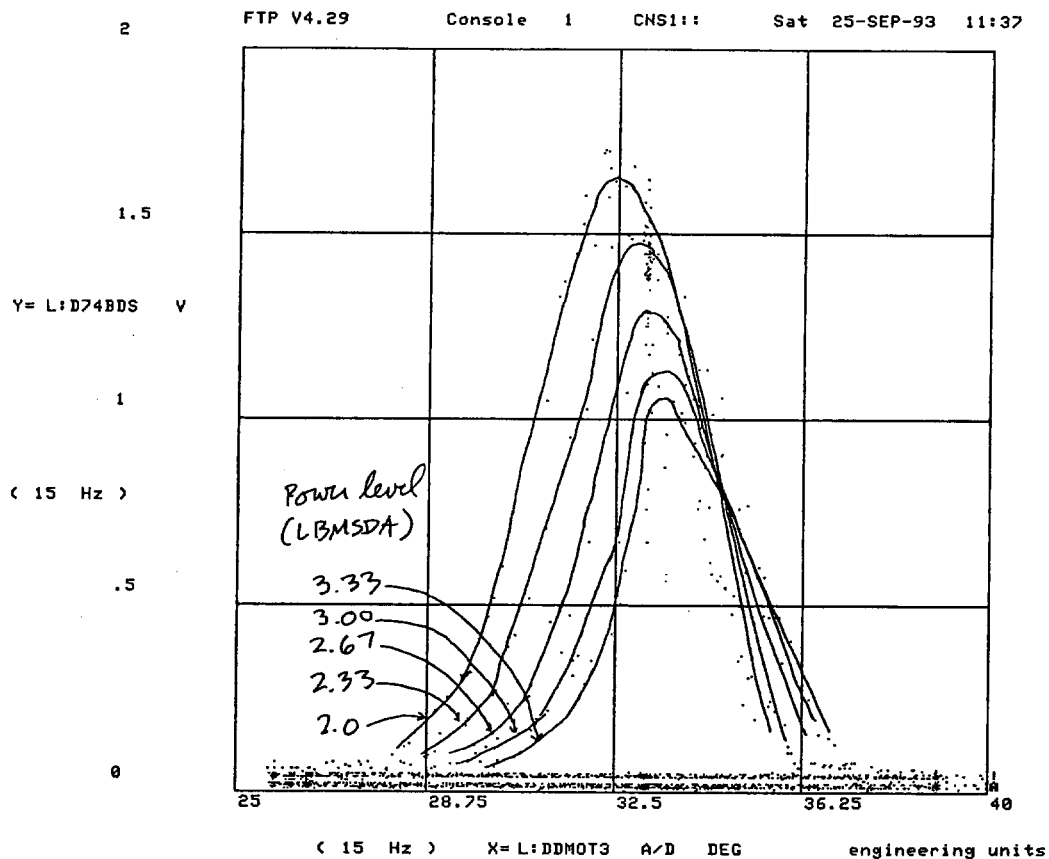
One possible reason might be that it represents the time arriving to the center of rf plate, as well the beam energy, change with the rf amplitude. The effect of the longitudinal field of the rf scanning plate is shown in Fig.2, the particle A is accelerated twice between the two end gap, however, the particle B is decelerated twice. The energy difference between particle A and B at the entrance of deflection plate can be roughly estimated in order of magnitude by:

$$\Delta W = \frac{d_b}{d} e V_{rf} \sin \frac{1}{2} \omega t_o \quad (4)$$

where  $d_b \sim 1$  mm is the beam width,  $t_o$  is the flight time between plate. In our case,  $V_{rf} \sim 1$  kV,  $\omega t_o \sim \pi$ , thus  $\Delta W \sim 50$  eV. However this only results in the energy divergency. When the beam injects into the plate with different energy, the flight time between the plates will be different, resulting in a different transverse deflection as well as a definite resolution. This may be estimated by:

$$\Delta t \doteq \frac{l_1}{\beta c \gamma (1 + \gamma)} \frac{\Delta W}{W} \quad (5)$$

where  $l_1 \approx 3$  cm is the length of deflection plate. For  $\Delta W = 50$  eV,  $W = 6$  keV,  $\Delta t \doteq 2.7$  ps ( $\sim 0.8^\circ$ ). According to the measured change in peak phase, the time change of peak is  $\sim 30$  ps in order, comparing with  $V_{rf} = 0$ . The reason is not



Console Location 1,  
Fast Time Plot

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Figure 1: The beam phase diagram vs. rf scanning amplitude

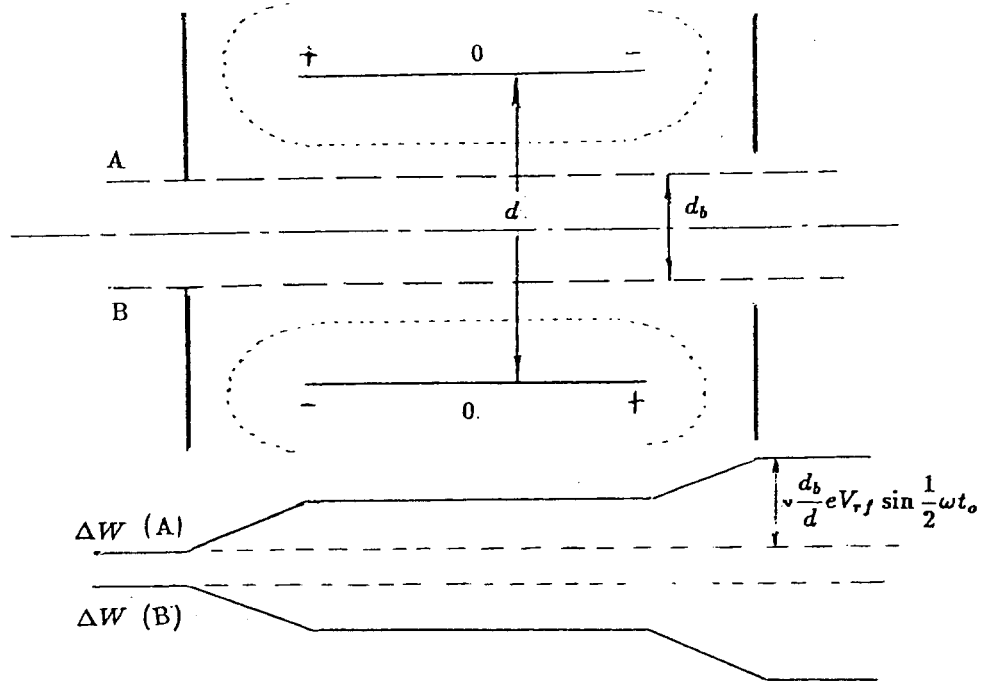


Figure 2: The effect of the longitudinal field of rf plate

clear, it may be impossible that such long time difference is caused by energy difference.

In conclusion:

- (1) The question about the resolution of BLD still needs to be studied carefully.
- (2) The further increase of the rf amplitude, reduction of the slit width, and careful tuning the electron beam focusing are useful for improvement of the resolution.
- (3) The further study of the beam phase diagram vs the rf amplitude and measuring the electron beam spot with and without beam are helpful.
- (4) Though the above phenomena can not be explained by the primary energy divergency of secondary electron, the measurement of this energy divergency is meaningful not only for this kind of beam diagnostic, but also it has an important theoretical value for the surface science, because, to my knowledge, all the data of the energy spectra of the secondary electron were measured at very low energy ( $\sim 10^2$  keV) and some experiment showed an energy divergency of  $\sim 10^2$  eV<sup>[3]</sup>, and it is possible to measure it at energy of 116—400 MeV here. For a primary measurement, only an small electrostatic analyzer (e.g.  $R \sim 20$  cm,  $d \sim 5$  mm,  $\Phi = 127.2^\circ$ ,  $V_d \sim 500$  V) is necessary.

## REFERENCES

- [1] LU-221 Huashun Zhang, "The resolution of the beam bunch length detector"
- [2] P.Ostroumov, Note of "BLD-3 Phase Resolution", 8, Oct. 1993.
- [3] A.C.Parilic, "A survey of Phenomena in Ionized Gases", p.309, Invited paper on the 8th Intern. Conf. on Phenomena in Ionized Gases, IAEA, Vienna,1968.